

Appendix E – Soil Cleanup Level and Remediation Level Calculations

E.1 Introduction

This appendix presents the calculations that were performed to develop the cleanup levels and remediation levels presented in Chapter 3. The equations used to calculate soil cleanup and remediation levels were obtained from the WAC 173-340-745. The EPA has chosen to evaluate the potential health effects of lead using a physiologically based model and the model equations and inputs are discussed in Chapter 3 of the RA.

The equations, inputs, and resulting cleanup or remediation levels are presented in the following tables:

- Table E-1 – Commercial Land Use Soil Remediation Levels.
- Table E-2 – Golf Course Land Use Soil Remediation Levels.
- Table E-3 – Historical Land Use Soil Remediation Levels.
- Table E-4 – Industrial Land Use Soil Cleanup Levels.
- Table E-5 – Open Space Land Use Soil Remediation Levels.

Table E-1 – Commercial Land Use Soil Remediation Levels

Constituent	RfD	CPF	ABW	Atn	Atc	UCF	SIR	AB1	EF	ED	Target HQ	Target Risk	Remediation Level (Noncarcinogenic) (mg/kg)	Remediation Level (Carcinogenic) (mg/kg)
Monomethylamine Nitrate	0.0081	NTV	70	7,300		1.0E+06	200	100%	52	20	1		19,900	NTV
Nitroglycerine	NTV	0.014	70		27,375	1.0E+06	200	100%	52	20		1.0E-05	NTV	6,580
2,4,6-Trinitrotoluene	0.0005	0.03	70	7,300	27,375	1.0E+06	200	100%	52	20	1	1.0E-05	1,230	3,071
Aluminum	1	NTV	70	7,300		1.0E+06	200	100%	52	20	1		2,457,000	NTV
Arsenic (inorganic)	0.0003	1.5	70	7,300	27,375	1.0E+06	200	100%	52	20	1	1.0E-05	737	61
Copper	0.037	NTV	70	7,300		1.0E+06	200	100%	52	20	1		90,900	NTV
Mercury	0.0003	NTV	70	7,300		1.0E+06	200	100%	52	20	1		737	NTV
Benzo(a)anthracene	NTV	0.73	70		27,375	1.0E+06	200	100%	52	20		1.0E-05	NTV	126
Benzo(a)pyrene	NTV	7.3	70		27,375	1.0E+06	200	100%	52	20		1.0E-05	NTV	12
Benzo(b)fluoranthene	NTV	0.73	70		27,375	1.0E+06	200	100%	52	20		1.0E-05	NTV	126
Benzo(k)fluoranthene	NTV	0.073	70		27,375	1.0E+06	200	100%	52	20		1.0E-05	NTV	1,262
Chrysene	NTV	0.0073	70		27,375	1.0E+06	200	100%	52	20		1.0E-05	NTV	12,620
Dibenz(a,h)anthracene	NTV	7.3	70		27,375	1.0E+06	200	100%	52	20		1.0E-05	NTV	12
Indeno(1,2,3-cd)pyrene	NTV	0.73	70		27,375	1.0E+06	200	100%	52	20		1.0E-05	NTV	126
Aldrin	3E-05	17	70	7,300	27,375	1.0E+06	200	100%	52	20	1	1.0E-05	73	5

Equation Input Values:

Input	Definition	Units
RfD	Noncancer Reference Dose	(mg/kg-day)
CPF	Cancer Potency Factor	(mg/kg-day) ⁻¹
ABW	Average Body Weight	(kg)
Atn	Averaging Time for Noncarcinogenic Effects	(days)
Atc	Averaging Time for Carcinogenic Effects	(days)
UCF	Unit Conversion Factor	(unitless)
SIR	Soil Ingestion Rate	(mg/day)
AB1	Gastrointestinal Absorption Rate	(unitless)
EF	Exposure Frequency	(days/year)
ED	Exposure Duration	(years)
Target HQ	Target Hazard Quotient for Noncarcinogenic Health Effects	(unitless)
Target Risk	Target Cancer Risk for Carcinogenic Health Effects	(unitless)

Notes:

NTV = No Toxicity Value. Not toxicity value was available from the sources presented in Chapter 3. Therefore, a remediation level could not be calculated.

Equations:

Noncarcinogenic Soil Remediation Level (mg/kg):

$$\frac{RfD \times ABW \times UCF \times HQ \times AT_n}{SIR \times AB1 \times EF \times ED}$$

Carcinogenic Soil Remediation Level:

$$\frac{Risk \times ABW \times UCF \times AT_c}{CPF \times ASIR \times B1 \times EF \times ED}$$

Table E-2 – Golf Course Land Use Soil Remediation Levels

Constituent	RfD	CPF	ABW	Atn	Atc	UCF	SIR	AB1	EF	ED	Target HQ	Target Risk	Remediation Level (Noncarcinogenic) (mg/kg)	Remediation Level (Carcinogenic) (mg/kg)
Monomethylamine Nitrate	0.0081	NTV	70	7,300		1.0E+06	200	100%	52	20	1		19,900	NTV
Nitroglycerine	NTV	0.014	70		27,375	1.0E+06	200	100%	52	20		1.0E-05	NTV	6,580
2,4,6-Trinitrotoluene	0.0005	0.03	70	7,300	27,375	1.0E+06	200	100%	52	20	1	1.0E-05	1,230	3,071
Aluminum	1	NTV	70	7,300		1.0E+06	200	100%	52	20	1		2,457,000	NTV
Arsenic (inorganic)	0.0003	1.5	70	7,300	27,375	1.0E+06	200	100%	52	20	1	1.0E-05	737	61
Copper	0.037	NTV	70	7,300		1.0E+06	200	100%	52	20	1		90,900	NTV
Mercury	0.0003	NTV	70	7,300		1.0E+06	200	100%	52	20	1		737	NTV
Benzo(a)anthracene	NTV	0.73	70		27,375	1.0E+06	200	100%	52	20		1.0E-05	NTV	126
Benzo(a)pyrene	NTV	7.3	70		27,375	1.0E+06	200	100%	52	20		1.0E-05	NTV	12
Benzo(b)fluoranthene	NTV	0.73	70		27,375	1.0E+06	200	100%	52	20		1.0E-05	NTV	126
Benzo(k)fluoranthene	NTV	0.073	70		27,375	1.0E+06	200	100%	52	20		1.0E-05	NTV	1,262
Chrysene	NTV	0.0073	70		27,375	1.0E+06	200	100%	52	20		1.0E-05	NTV	12,620
Dibenz(a,h)anthracene	NTV	7.3	70		27,375	1.0E+06	200	100%	52	20		1.0E-05	NTV	12
Indeno(1,2,3-cd)pyrene	NTV	0.73	70		27,375	1.0E+06	200	100%	52	20		1.0E-05	NTV	126
Aldrin	3E-05	17	70	7,300	27,375	1.0E+06	200	100%	52	20	1	1.0E-05	73	5

Equation Input Values:

Input	Definition	Units
RfD	Noncancer Reference Dose	(mg/kg-day)
CPF	Cancer Potency Factor	(mg/kg-day) ⁻¹
ABW	Average Body Weight	(kg)
Atn	Averaging Time for Noncarcinogenic Effects	(days)
Atc	Averaging Time for Carcinogenic Effects	(days)
UCF	Unit Conversion Factor	(unitless)
SIR	Soil Ingestion Rate	(mg/day)
AB1	Gastrointestinal Absorption Rate	(unitless)
EF	Exposure Frequency	(days/year)
ED	Exposure Duration	(years)
Target HQ	Target Hazard Quotient for Noncarcinogenic Health Effects	(unitless)
Target Risk	Target Cancer Risk for Carcinogenic Health Effects	(unitless)

Notes:

NTV = No Toxicity Value. Not toxicity value was available from the sources presented in Chapter 3. Therefore, a remediation level could not be calculated.

Equations:

Noncarcinogenic Soil Remediation Level (mg/kg):

$$\frac{RfD \times ABW \times UCF \times HQ \times AT_n}{SIR \times AB1 \times EF \times ED}$$

Carcinogenic Soil Remediation Level:

$$\frac{Risk \times ABW \times UCF \times AT_c}{CPF \times ASIR \times B1 \times EF \times ED}$$

Table E-3 – Historical Land Use Soil Remediation Levels

Constituent	RfD	CPF	ABW	Atn	Atc	UCF	SIR	AB1	EF	ED	Target HQ	Target Risk	Remediation Level (Noncarcinogenic) (mg/kg)	Remediation Level (Carcinogenic) (mg/kg)
Monomethylamine Nitrate	0.0081	NTV	47	4,380		1.0E+06	200	100%	104	12	1		6,681	NTV
Nitroglycerine	NTV	0.014	47	NTV	2,7375	1.0E+06	200	100%	104	12		1.0E-06	NTV	368
2,4,6-Trinitrotoluene	0.0005	0.03	47	4,380	2,7375	1.0E+06	200	100%	104	12	1	1.0E-06	412	172
Aluminum	1	NTV	47	4,380		1.0E+06	200	100%	104	12	1		825,000	NTV
Arsenic (inorganic)	0.0003	1.5	47	4,380	27,375	1.0E+06	200	100%	104	12	1	1.0E-06	247	3
Copper	0.037	NTV	47	4,380		1.0E+06	200	100%	104	12	1		30,516	NTV
Mercury	0.0003	NTV	47	4,380		1.0E+06	200	100%	104	12	1		247	NTV
Benzo(a)anthracene	NTV	0.73	47		27,375	1.0E+06	200	100%	104	12		1.0E-06	NTV	7
Benzo(a)pyrene	NTV	7.3	47		27,375	1.0E+06	200	100%	104	12		1.0E-06	NTV	0.71
Benzo(b)fluoranthene	NTV	0.73	47		27,375	1.0E+06	200	100%	104	12		1.0E-06	NTV	7
Benzo(k)fluoranthene	NTV	0.073	47		27,375	1.0E+06	200	100%	104	12		1.0E-06	NTV	70
Chrysene	NTV	0.0073	47		27,375	1.0E+06	200	100%	104	12		1.0E-06	NTV	706
Dibenz(a,h)anthracene	NTV	7.3	47		27,375	1.0E+06	200	100%	104	12		1.0E-06	NTV	0.71
Indeno(1,2,3-cd)pyrene	NTV	0.73	47		27,375	1.0E+06	200	100%	104	12		1.0E-06	NTV	7
Aldrin	0.00003	17	47	4,380	27,375	1.0E+06	200	100%	104	12	1	1.0E-06	24	0.30

Equation Input Values:

Input	Definition	Units
RfD	Noncancer Reference Dose	(mg/kg-day)
CPF	Cancer Potency Factor	(mg/kg-day) ⁻¹
ABW	Average Body Weight	(kg)
Atn	Averaging Time for Noncarcinogenic Effects	(days)
Atc	Averaging Time for Carcinogenic Effects	(days)
UCF	Unit Conversion Factor	(unitless)
SIR	Soil Ingestion Rate	(mg/day)
AB1	Gastrointestinal Absorption Rate	(unitless)
EF	Exposure Frequency	(days/year)
ED	Exposure Duration	(years)
Target HQ	Target Hazard Quotient for Noncarcinogenic Health Effects	(unitless)
Target Risk	Target Cancer Risk for Carcinogenic Health Effects	(unitless)

Notes:

NTV = No Toxicity Value. Not toxicity value was available from the sources presented in Chapter 3. Therefore, a remediation level could not be calculated.

Equations:

Noncarcinogenic Soil Remediation Level (mg/kg):

$$\frac{RfD \times ABW \times UCF \times HQ \times AT_n}{SIR \times AB1 \times EF \times ED}$$

Carcinogenic Soil Remediation Level:

$$\frac{Risk \times ABW \times UCF \times AT_c}{CPF \times ASIR \times B1 \times EF \times ED}$$

Table E-4 – Industrial Land Use Soil Cleanup Levels

Constituent	RfD	CPF	ABW	Atn	Atc	UCF	SIR	AB1	EF	ED	Target HQ	Target Risk	Remediation Level (Noncarcinogenic) (mg/kg)	Remediation Level (Carcinogenic) (mg/kg)
Monomethylamine Nitrate	0.0081	NTV	70	7,300		1.0E+06	50	100%	145	20	1		28,546	NTV
Nitroglycerine	NTV	0.014	70		27,375	1.0E+06	50	100%	145	20		1.0E-05	NTV	9,440
2,4,6-Trinitrotoluene	0.0005	0.03	70	7,300	27,375	1.0E+06	50	100%	145	20	1	1.0E-05	1,762	4,405
Aluminum	1	NTV	70	7,300		1.0E+06	50	100%	145	20	1		3,524,137	NTV
Arsenic (inorganic)	0.0003	1.5	70	7,300	27,375	1.0E+06	50	100%	145	20	1	1.0E-05	1,057	88
Copper	0.037	NTV	70	7,300		1.0E+06	50	100%	145	20	1		130,393	NTV
Mercury	0.0003	NTV	70	7,300		1.0E+06	50	100%	145	20	1		1,057	NTV
Benzo(a)anthracene	NTV	0.73	70		27,375	1.0E+06	50	100%	145	20		1.0E-05	NTV	181
Benzo(a)pyrene	NTV	7.3	70		27,375	1.0E+06	50	100%	145	20		1.0E-05	NTV	18
Benzo(b)fluoranthene	NTV	0.73	70		27,375	1.0E+06	50	100%	145	20		1.0E-05	NTV	181
Benzo(k)fluoranthene	NTV	0.073	70		27,375	1.0E+06	50	100%	145	20		1.0E-05	NTV	1,810
Chrysene	NTV	0.0073	70		27,375	1.0E+06	50	100%	145	20		1.0E-05	NTV	18,103
Dibenz(a,h)anthracene	NTV	7.3	70		27,375	1.0E+06	50	100%	145	20		1.0E-05	NTV	18
Indeno(1,2,3-cd)pyrene	NTV	0.73	70		27,375	1.0E+06	50	100%	145	20		1.0E-05	NTV	181
Aldrin	0.00003	17	70	7,300	27,375	1.0E+06	50	100%	145	20	1	1.0E-05	105	7

Equation Input Values:

Input	Definition	Units
RfD	Noncancer Reference Dose	(mg/kg-day)
CPF	Cancer Potency Factor	(mg/kg-day) ⁻¹
ABW	Average Body Weight	(kg)
Atn	Averaging Time for Noncarcinogenic Effects	(days)
Atc	Averaging Time for Carcinogenic Effects	(days)
UCF	Unit Conversion Factor	(unitless)
SIR	Soil Ingestion Rate	(mg/day)
AB1	Gastrointestinal Absorption Rate	(unitless)
EF	Exposure Frequency	(days/year)
ED	Exposure Duration	(years)
Target HQ	Target Hazard Quotient for Noncarcinogenic Health Effects	(unitless)
Target Risk	Target Cancer Risk for Carcinogenic Health Effects	(unitless)

Notes:

NTV = No Toxicity Value. Not toxicity value was available from the sources presented in Chapter 3. Therefore, a remediation level could not be calculated.

Equations:

Noncarcinogenic Soil Remediation Level (mg/kg):

$$\frac{RfD \times ABW \times UCF \times HQ \times AT_n}{SIR \times AB1 \times EF \times ED}$$

Carcinogenic Soil Remediation Level:

$$\frac{Risk \times ABW \times UCF \times AT_c}{CPF \times ASIR \times B1 \times EF \times ED}$$

Table E-5 – Open Space Land Use Soil Remediation Levels

Constituent	RfD	CPF	ABW	Atn	Atc	UCF	SIR	AB1	EF	ED	Target HQ	Target Risk	Remediation Level (Noncarcinogenic) (mg/kg)	Remediation Level (Carcinogenic) (mg/kg)
Monomethylamine Nitrate	0.0081	NTV	47	4,380		1.0E+06	200	100%	104	12	1		6,681	NTV
Nitroglycerine	NTV	0.014	47		27,375	1.0E+06	200	100%	104	12		1.0E-06	NTV	368
2,4,6-Trinitrotoluene	0.0005	0.03	47	4,380	27,375	1.0E+06	200	100%	104	12	1	1.0E-06	412	172
Aluminum	1	NTV	47	4,380		1.0E+06	200	100%	104	12	1		824,759	NTV
Arsenic (inorganic)	0.0003	1.5	47	4,380	27,375	1.0E+06	200	100%	104	12	1	1.0E-06	247	3
Copper	0.037	NTV	47	4,380		1.0E+06	200	100%	104	12	1		30,516	NTV
Mercury	0.0003	NTV	47	4,380		1.0E+06	200	100%	104	12	1		247	NTV
Benzo(a)anthracene	NTV	0.73	47		27,375	1.0E+06	200	100%	104	12		1.0E-06	NTV	7
Benzo(a)pyrene	NTV	7.3	47		27,375	1.0E+06	200	100%	104	12		1.0E-06	NTV	0.71
Benzo(b)fluoranthene	NTV	0.73	47		27,375	1.0E+06	200	100%	104	12		1.0E-06	NTV	7
Benzo(k)fluoranthene	NTV	0.073	47		27,375	1.0E+06	200	100%	104	12		1.0E-06	NTV	70
Chrysene	NTV	0.0073	47		27,375	1.0E+06	200	100%	104	12		1.0E-06	NTV	706
Dibenz(a,h)anthracene	NTV	7.3	47		27,375	1.0E+06	200	100%	104	12		1.0E-06	NTV	0.71
Indeno(1,2,3-cd)pyrene	NTV	0.73	47		27,375	1.0E+06	200	100%	104	12		1.0E-06	NTV	7
Aldrin	0.00003	17	47	4,380	27,375	1.0E+06	200	100%	104	12	1	1.0E-06	24	0.30

Equation Input Values:

Input	Definition	Units
RfD	Noncancer Reference Dose	(mg/kg-day)
CPF	Cancer Potency Factor	(mg/kg-day) ⁻¹
ABW	Average Body Weight	(kg)
Atn	Averaging Time for Noncarcinogenic Effects	(days)
Atc	Averaging Time for Carcinogenic Effects	(days)
UCF	Unit Conversion Factor	(unitless)
SIR	Soil Ingestion Rate	(mg/day)
AB1	Gastrointestinal Absorption Rate	(unitless)
EF	Exposure Frequency	(days/year)
ED	Exposure Duration	(years)
Target HQ	Target Hazard Quotient for Noncarcinogenic Health Effects	unitless)
Target Risk	Target Cancer Risk for Carcinogenic Health Effects	(unitless)

Notes:

NTV = No Toxicity Value. Not toxicity value was available from the sources presented in Chapter 3. Therefore, a remediation level could not be calculated.

Equations:

Noncarcinogenic Soil Remediation Level (mg/kg):

$$\frac{RfD \times ABW \times UCF \times HQ \times AT_n}{SIR \times AB1 \times EF \times ED}$$

Carcinogenic Soil Remediation Level:

$$\frac{Risk \times ABW \times UCF \times AT_c}{CPF \times ASIR \times B1 \times EF \times ED}$$